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IV. *Descriptions of the King's Wells at Sheernefs, Languard-Fort, and Harwich. By Sir Thomas Hyde Page, Knt. F. R. S.; communicated by Lieut. Gen. Rainsford, F. R. S.*

Read November 13, 1783.

LIEUT. GEN. RAINSFORD.

S I R,

St. Margaret's-Street,
March 28, 1783.

I HAD the pleasure to receive your obliging letter of the 28th ult. mentioning, that it would be satisfactory to the Royal Society to have a description of the wells at Sheernefs, Harwich, and Languard-Fort, which were made under my direction, whilst I commanded as Engineer at those places.

I beg to acquaint you, that it will be necessary to mention some previous circumstances that occasioned those undertakings, which will rather interfere with the descriptive part, and I fear intrude on the patience of the Society; but I shall in this respect hope for their indulgence, it being my wish to explain the nature of the different operations as fully as possible, that similar situations, where water is wanted, may receive benefit from the experiments I have had the good fortune to succeed in; and it cannot fail of affording me the highest satisfaction to have an opportunity of communicating this subject to the knowledge of the public through the Royal Society.

I have only further to request, that you will do me the honour to lay the following descriptions before Sir JOSEPH BANKS and the Society; and as you are fully acquainted with the subject, you will confer on me an additional favour by explaining the several parts (if requisite) more fully than I have done in the written account, when it is under consideration.

I am, &c.

Some circumstances respecting the garrisons of Sheerneys, Landguard-Fort, and the Town of Harwich, with a description of the wells which supply water for the use of the troops, &c. at each place.

The Master-general of the Ordnance (Lord TOWNSHEND) in the beginning of the year 1778, recommended to his Majesty, that the fortifications upon the Eastern Coast, including Dover, Sheerneys, Landguard-Fort, and some other places, should be repaired, and new works added, where they might appear necessary towards a proper state of defence, if a war with Holland, or other Northern powers, was found unavoidable. His lordship foresaw the great objection to fortifications, in the want of fresh water under the command of the guns of our garrisons; and I had directions accordingly to consider the subject, and report to his lordship and the Board of Ordnance any ideas that might be likely to remedy so great a defect.

The dock-yard and garrison at Sheerneys were supplied with water from Chatham at an enormous expence, near two thousand

sand pounds *per annum*, or occasionally from Queenborough, neither of which supplies could be continued in case of a siege, which of course would be of short duration from this circumstance. Some attempts had been made in former times to obtain water on the spot, by sinking wells, but they had failed; and success in such undertakings was at last considered as impossible, from the great difficulty they had met with in the vast quantities of sea-water, that came by filtration through the sands into their wells, and rendered a progress to any considerable depth impracticable. It is probable, that the course of the river Medway has undergone many changes, and had once an out-fall to the sea, near the high ground of the Isle of Shepey. The docks, garrisons, buildings, &c. for a considerable distance into the island, consequently stand upon very loose materials, which were found, upon sinking the well in Fort Townshend, to consist of mud, sea-beach, and quicksand, nearly to the present depth of the river Medway, and admit so strong a filtration of salt-water, as must ever render the sinking of wells exceedingly difficult. This was the situation in which I found Sheerness.

Landguard-Fort was not more eligible respecting water, as a place of strength. It was, indeed, better supplied under any other consideration, a pipe being laid into the place from a good spring about two miles distant, which furnished a plentiful quantity of water; but such is the disadvantage of situation that, in case of attack, that spring must fall into the possession of the enemy, and our garrison of course would be deprived of its use. This was a serious consideration and objection to a great extent of fortification, however eligible in other respects the place might be.

Harwich was judged by the Commander in Chief (Lord AMHERST) to be a very proper station for a considerable part of the army, in time of war with Holland, as central to furnish detachments for such parts of the coast as might be in danger, as also to cover a very useful harbour and increasing dock-yard; but his lordship was sensible of the want of wholesome water in that neighbourhood, and gave particular directions to establish such a supply for the camp to be formed there, as might appear proper for the health of the troops; and the subsequent orders given by General RAINSFORD, who commanded that district, perfectly answered every desirable end, until good water was found within his camp. The inhabitants of the town of Harwich had chiefly depended on rains for their supply, the wells being in general brackish from the filtration of salt-water. The neighbourhood, to many miles distance, was not better furnished, there being only stagnating water in ponds or shallow wells, which were supplied from the upper surface of the ground; and, whether rendered bad by a mixture of copperas, or other mineral, it was not such as could be given for the use of the troops with any degree of prudence or attention to their health, and they were, to avoid dangerous consequences, furnished with water, by General RAINSFORD's order, from the opposite side of the Manningtree River, by boats employed for that purpose, the beginning of the first campaign.

I will now endeavour to describe the experiments at each place, beginning with the well in Fort Townshend at Sheerness, which with a reference to the plans will, I hope, render the subject sufficiently intelligible.

King's Well, Fort Townshend, Sheernefs.

This undertaking was at first considered as a mere experiment, the probability of success being much against it; I however thought the attempt, where a dock-yard of great consequence to the navy was established, should be made, and carried as far as it could, with a proper attention to œconomy in laying out the money of the public. Such was my opinion signified to the Master-general and the Board of Ordnance. I received an answer thereto, expressive of approbation, and full powers to employ proper persons, and proceed upon the undertaking.

These previous steps seemed highly necessary, as in all works of difficulty, great confidence is as much required as able workmen or good plans.

The favourable opinion his Majesty was graciously pleased to express publicly of the project, when he visited Sheernefs, and saw the well, tended very much towards its final success; and the countenance and support of General CRAIG, governor of that garrison, greatly promoted perseverance in a work of such difficulty.

I employed a very ingenious man, Mr. COLE, engine-maker, of Lambeth, as a chief person in this business, and received every assistance I expected from his experience and judgement in mechanics; and it is but justice to him to express, that the success of the work greatly depended on his attention and the able assistants he procured from distant parts of the kingdom.

The greatest acknowledgement is also due to the ability of Lieut. HUMFRYS, of the Engineers, and Mr. MARSHALL, the Ordnance-overseer, who were constantly on the spot, and car-

ried my orders into execution with the greatest zeal for the success of the undertaking as well as judgement. The mentioning these gentlemen's names is, as well as a justice to their conduct, to recommend harmony and mutual exertion in any future work of this nature, as, without an equal attention in every one, I should greatly doubt success, even admitting the same plan to be in all other respects strictly attended to, as there would be great difficulty and danger to the lives of the workmen if carelessly carried on.

The work was begun the 4th of June, 1781, and finished the 4th of July, 1782.

A circle of twenty-two feet diameter was first marked out on the ground, and the space excavated to the depth of five feet; after which, pieces of wood, called ribs, upon the curve of a diameter twenty-one feet four inches, and about nine inches scantling, were placed, to form a complete circle within the excavated part at the bottom, above which other circles of the same nature were placed, and supported by upright pieces of scantlings, having short boards introduced by the intervals, which afterwards pressed upon the circles or ribs, between them and the exterior parts. These, when united, formed one frame of wood from the bottom to the top, or rather higher than the excavated space, and prevented the mud of the upper surface, which was very soft, from falling in upon the workmen. In proceeding deeper, care was taken to prevent the sinking of the before-mentioned frame by its own weight, in excavating parts only under it till another circle of pieces like the first, called ribs, was formed, and uprights, with boards behind, introduced. The distance between these circles was in the first, or upper part of the work, about three feet; but as difficulties increased they were placed nearer, and

in many parts joined each other without any boards or uprights (as will appear in the section of the plan), and continued through the whole of the wooden frame, against the weight of the mud, quick-sand, and sea-beach, to the depth of thirty-six feet.

The reason of the circular frames being nearer in some parts than in others, arose from the greater or less quantity of salt-water that came through the sands, &c. and often rendered it impossible to sink under the frame more than the thickness of one of the ribs, without danger of blowing up, or of the sides behind the wood slipping with the streams of water, and thereby forcing into the bottom of the well, which in sinking through very wet quick-sand is much to be apprehended; and an accident of that nature would entirely destroy the work. An attention to the plan will shew at what depths the filtration of water was most dangerous, and the difficulties at different periods, may be estimated by the distance of the circles, formed of ribs, from each other, and where they appear to join, it was not without the utmost efforts of labour that the work could be carried on. At the depth of thirty-six feet the wood-work was finished, and six feet deeper a firm foundation of hard blue clay discovered. The several parts of the frame were then strengthened wherever it appeared necessary, to prevent separation, and to resist the immense pressure of soft mud, quick-sand, and loose sea-beach, which were supported by it.

It must be observed, that the salt-water, after proceeding thus far, came in very fast through all the joints of the frame, and that holes were left on purpose in certain parts to let it run into the well, that it might not be confined entirely to the bottom of the work, which, from the weight upon one part
only,

only, might have blown, which is ever (as has been observed) to be guarded against with the utmost caution.

The frame being found of sufficient strength, and the workmen able, by constant drawing with four 36-gallon buckets, to keep the bottom of the well dry enough to proceed further, the greatest difficulty seemed to be overcome. The next process was to cut off or stop the salt-water out entirely: to effect which, a smaller circle was described at the bottom of the well, upon the hard clay already mentioned, of the diameter of eight feet in the clear, round which a curb, or circular frame of wood, was laid, and a brick steening, of two bricks thick in tarris, raised gradually towards the top of the well, whilst, as it proceeded upwards, the space between the back of this steening and the wooden frame (fixed six feet higher) was filled with good tempered clay, four feet thick, and carefully rammed. During this operation, and raising the brick-work, with the clay behind it, the water continued to run over them into the center of the well, now reduced to eight feet diameter, and was constantly drawn out, to leave the workmen on the sides sufficiently dry to raise their work until they had reached the top, and consequently, as it was water-tight, cut off the filtration from the sea, precautions having been taken to prevent the danger of blowing at the bottom.

The next proceeding appeared more simple; but great care was still necessary to avoid damaging the foundation of the works already done, as the least crack might have again introduced the salt-water. A smaller circle than the last was therefore described, and ribs, forming circles of wood, raised some feet within the brick-work; and others, of the same form, were sunk to the depth of eight feet below the bottom, upon which the several works already described rested. After this a
course

course of bricks was carried up within the last mentioned ribs or circles, upon a diameter of six feet, whereby they became inclosed and joined with the first mentioned brick-work, having the clay wall and wooden frame pressing behind them upon larger diameters. In sinking lower, small curbs were at certain distances (as will appear in the section of the plan) placed to support the steening, which consisted of two stretching courses of bricks, laid separately, and keyed into the clay or back part of the brick-work by rough pieces of stone, flint, &c. to prevent a slipping or lowering of the steening by its own weight. The work was carried on from this period, without any material difficulty or difference in the clay (except the very extraordinary discovery of a piece of a tree at the depth of 300 feet from the top of the well, which is shewn in the plan) until the appearance of water at 328 feet deep, by a small mixture of sand in the clay, with oozing of water from it; and at 330 feet deep, upon boring, the whole bottom of the well blew up, and it was with difficulty the workmen escaped the torrents of water that followed them, which was mixed with a quick-sand that rose forty feet in the bottom of the well, at which height it still remains. The water rose in six hours 189 feet, and in a few days within eight feet of the top of the well. It has since been carefully analyzed by a chemist, and found perfectly good for every purpose; and, it is presumed, the quantity will be equal to every demand of public and private use at that place, as there has been, ever since it was first discovered, a constant drawing of water, and it has hitherto been found impossible to lower the well more than 200 feet, there has consequently always been a depth left in water of 130 feet. It is to be remarked, that the water is of a very soft quality, and, upon being drawn, has a degree of warmth unusual in common

common well-water. It remains yet to be determined whence that warmth proceeds; but as it proved wholesome, the circumstance is fortunate for the soldiers of the garrison, as they will not be liable to complaints that are so frequent among troops (as often happens at Dover Castle) from imprudence in drinking great quantities of very cold well-water.

King's Wells at Landguard-Fort.

They were begun and finished in the year 1782.

The peculiar situation of this fort made it very unlikely that springs of fresh-water could ever be found, there being great reason to think, that the out-fall of the Ipswich and Manning-tree Rivers, which unite before they reach the sea, was formerly on the Suffolk side of the fort, but is now on the Essex side; and as the garrison, in ancient writings, is described to have been built on the Andrew's Sand, there appeared little probability of any filtration of water through it, except that of the sea. It, however, seemed proper to try the possibility of sinking through it, to endeavour to find a hard bottom, similar to that discovered at Sheernefs, fresh-water being of vast consequence to the defence of the place. The work was accordingly begun; but about the same time, in making the excavation of a ditch for one of the batteries, at a very few feet from the upper surface of the sand, a small quantity of fresh-water was perceived; and it was chance that led to a discovery of its freshness, from one of the labourers happening to taste it. The circumstance

circumstance was reported to me by Mr. ROBERTS, the Adjutant of the Works; and we, upon examining further, found that the quantity of water upon sinking was considerable, and that it appeared perfectly fresh. I then ordered the well-sinkers to proceed to this depth at another place, where they found a like appearance of good water; and the quantity was so great, as to render it very difficult to keep the bottom of the well, at twelve feet deep, dry enough to sink further. Every exertion was notwithstanding used, and with great labour a well was sunk to the depth of low water mark at spring tides, about eighteen feet from the upper surface of the sand; when, to the surprize of every person, the water that rose from the bottom became, on a sudden, entirely salt. This put an end to the work for a time, as it seemed impossible to penetrate deeper. I then considered the matter very differently with my first idea, and though the impossibility of having a deep well clearly appeared, there remained a prospect of a sufficient supply of good fresh water. It may now be necessary to recollect, that at a very few feet from the surface (eight feet) there was good water; that it continued in vast quantity almost to the spring tide low-water-mark, after which the salt-water had appeared; I therefore directed sand to be thrown into the well, to bring it a little above what had been the *lowest fresh-water* line (twelve feet from the upper surface) and then drew the water out which had mixed. After this, the filtration into the well became again perfectly fresh, and in equal quantity to the first appearance. This was, therefore, fixed as the greatest depth (twelve feet) and another well sunk at forty feet distance, with a horizontal brick drain, having holes left in the sides for filtration, as described in the plan, to collect the water, and the bottoms of both wells were secured with hard materials; that the whole

supply

supply of water might be reduced to the drain, which is constructed to prevent as much as possible the mixture of sand with the water, and is found to answer the desired end. This success arose from various unexpected circumstances; but I am yet at a loss for the cause of the fresh water, or whence it comes.

I conceive, that there is a certain distance from the sea, upon every sandy shore, to which the salt-water penetrates, where it is forced whilst the tide is at its greatest height; and that such water, when so far pressed into the sands, has an action back towards the sea again, as *the tide falls*, and continues to have it until another tide makes it revert; this may account for the filtration of salt-water a certain way into a country; and that further, from *probably higher surfaces*, there may be fresh-water in the same continuation of sands, and the separation discoverable to a degree of great accuracy; whether this action of salt-water in the sand, by friction, can render it fresh, or of a less degree of salt, I will not pretend to judge. I presume the contrary; but am even under that idea at a loss to know how so much fresh water gets into the sand at Landguard-Fort, it being so entirely separated from the spring of the country. It is evident, upon a full consideration of the subject, that the sea, to the height of *low water*, will penetrate a vast distance into a sandy country, by filtration, and to that height *only*, it having so far a constant pressure, and no re-action; the water, therefore, being once in the sand, can never return by the same passage, the cause of its entrance still remaining; whereas in the higher surfaces, the *rise* and *fall* of tides must keep it in constant movement, and the distance of filtration will bear a proportion to the duration of pressure which gave it original motion. It is probably not so easy to account for a body of

fresh-water being to the depth of twelve feet in the sand, and in the same line, a few feet deeper, the water should be entirely salt, and that they do not mix together. Whether the greater specific gravity of the salt-water is sufficient to prevent a mixture with the fresh upon a higher line, I cannot venture to say; but the fact of there being a separation is beyond a doubt, and the depths may be ascertained to a degree of great accuracy. However this may be accounted for, the discovery at Landguard-Fort is of very great consequence to the garrison; and there is reason to think, that in similar situations, where water is wanted, an attention to what has been already explained may be found of use.

King's Wells at Harwich.

They were begun the 6th of May, 1781, upon General RAINSFORD's taking the command at that camp, and finished the 29th of September following.

The wells in this neighbourhood, as has already been observed, being very shallow, and only depending on springs from the upper surfaces of the ground, have but little water in the summer, and the quality of it is very bad. The best of the old wells was in the rear of General RAINSFORD's camp, and was thought of at first for the use of the troops; but he prudently declined that supply. It was imagined, as the water from the upper surface was of a bad quality, that the most likely way to obtain a better spring was to sink a well from higher ground, and to endeavour to penetrate through a rock which lay a few yards under the level of the country, although the operation might be tedious, upon the chance of cutting a spring

spring of better water, that might be unconnected with the land-drains. The experiment answered in every respect, as there was not a drop of water found till the rock had been entirely cut through, when, upon finding a considerable quantity of moist sand, and boring into it, a plentiful spring was discovered, and has supplied the troops ever since with very good water. It is probable this supply, the spring being very powerful, will be found equal to every demand for public and private purposes, in the driest seasons. After this success, as matter of curiosity, an old well was made deeper, by excavating through the rocks, where a good spring was also found; but as that well had been originally sunk from low ground, a great deal of the bad water from the upper drains, &c. mixes with it, and gives it a disagreeable taste.

The plans will describe the manner of making these wells sufficiently. I have chiefly dwelt on the descriptive part, to recommend, where it is apprehended any mineral or drain from the upper surface of lands, by mixing in wells, may hurt the water, the sinking from the heights, as there are few countries where very good water may not be found, by a proper attention to locality in making wells.

EXPLANATION OF THE PLATES.

Tab. I. fig. 1. Section of the King's Well in Fort Townshend at Sheernefs.

2. Plan of the frame and well.
3. Section of the frame AA.
4. Plan of the well.

Tab. II. X. Line of high-water mark.

Y. Line of low-water mark.

Z. Line of low-water at spring-tides.

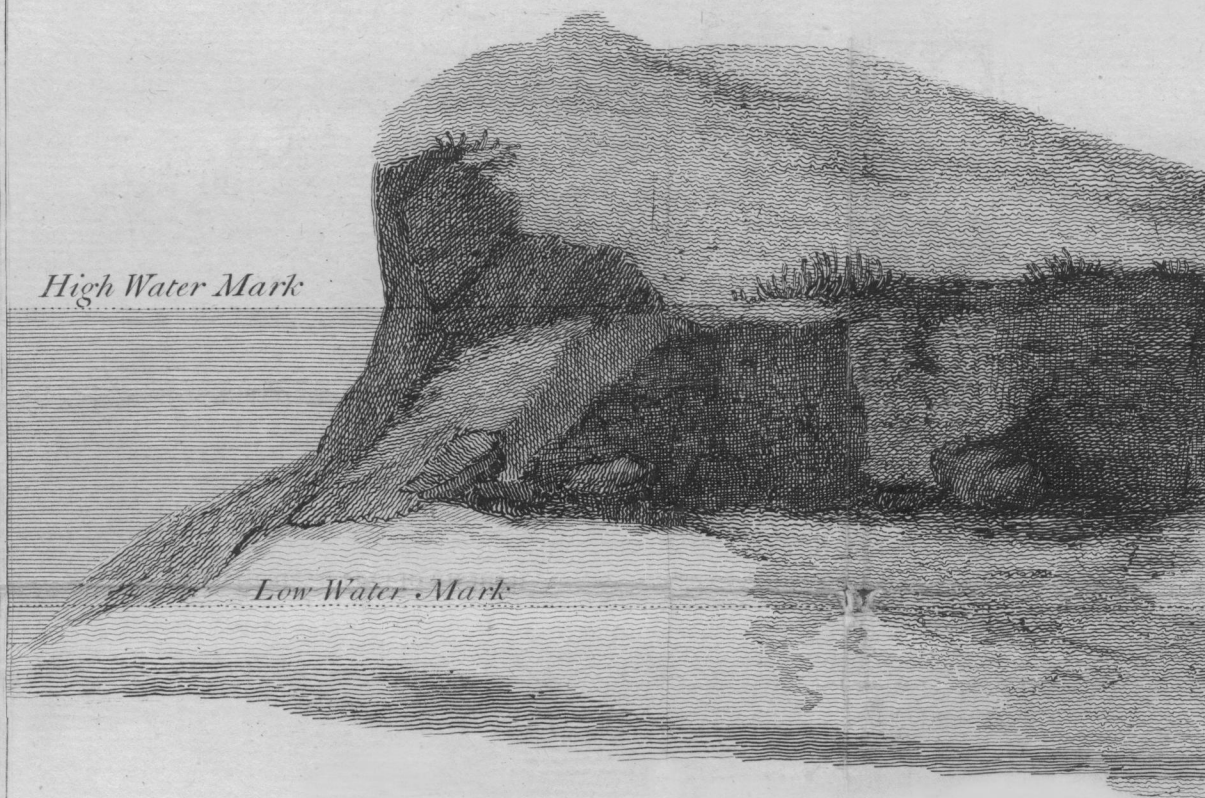


Fig. 4.

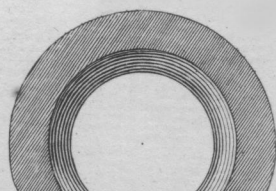
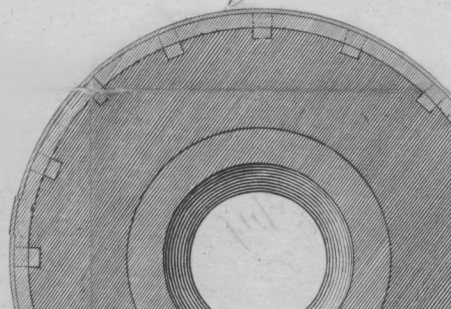


Fig. 2.



King's Well, Fort Townshend

Fig. 1.

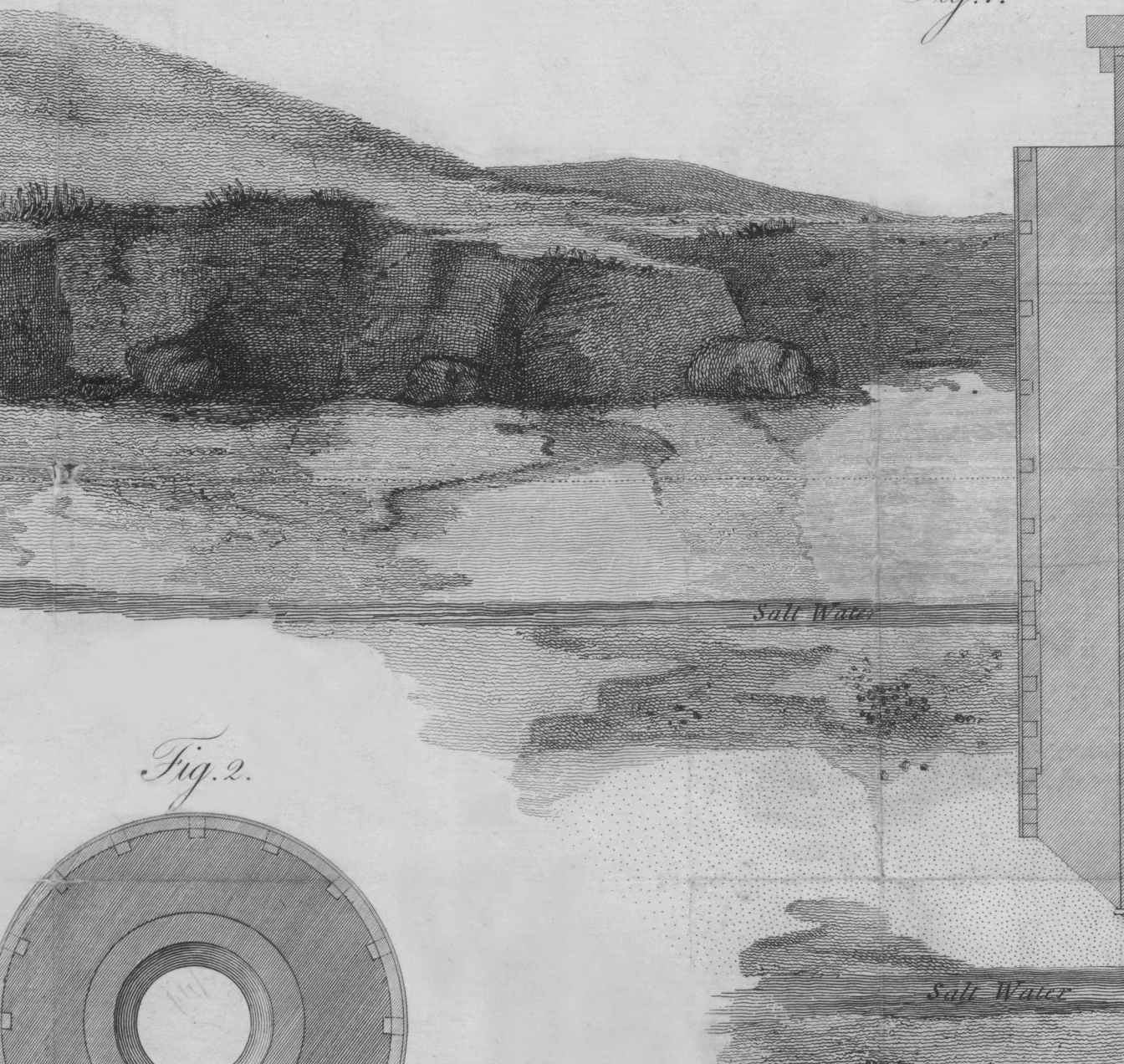
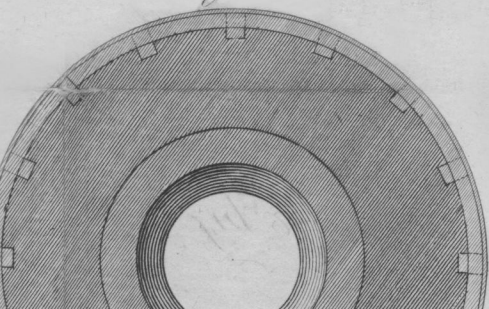
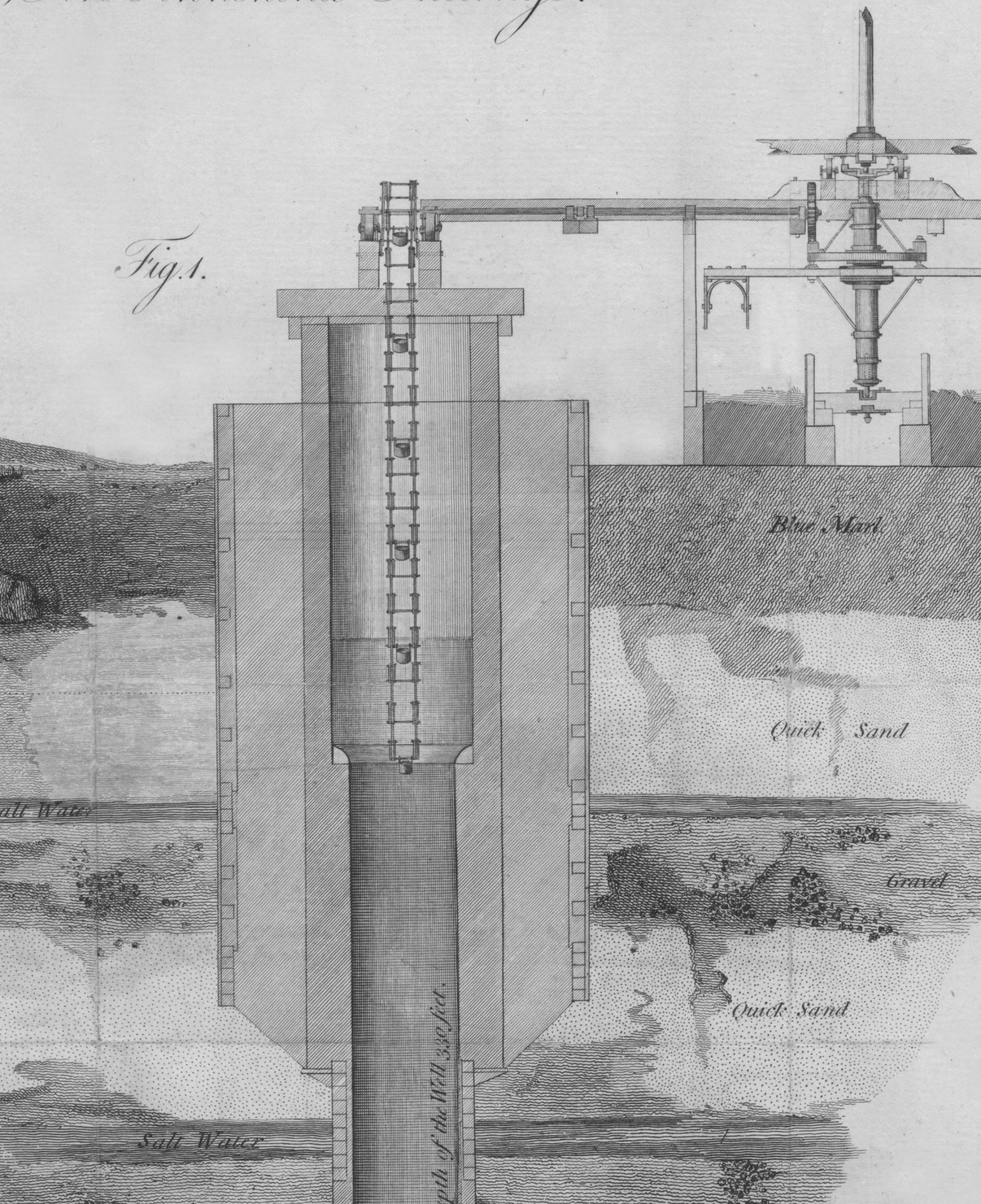


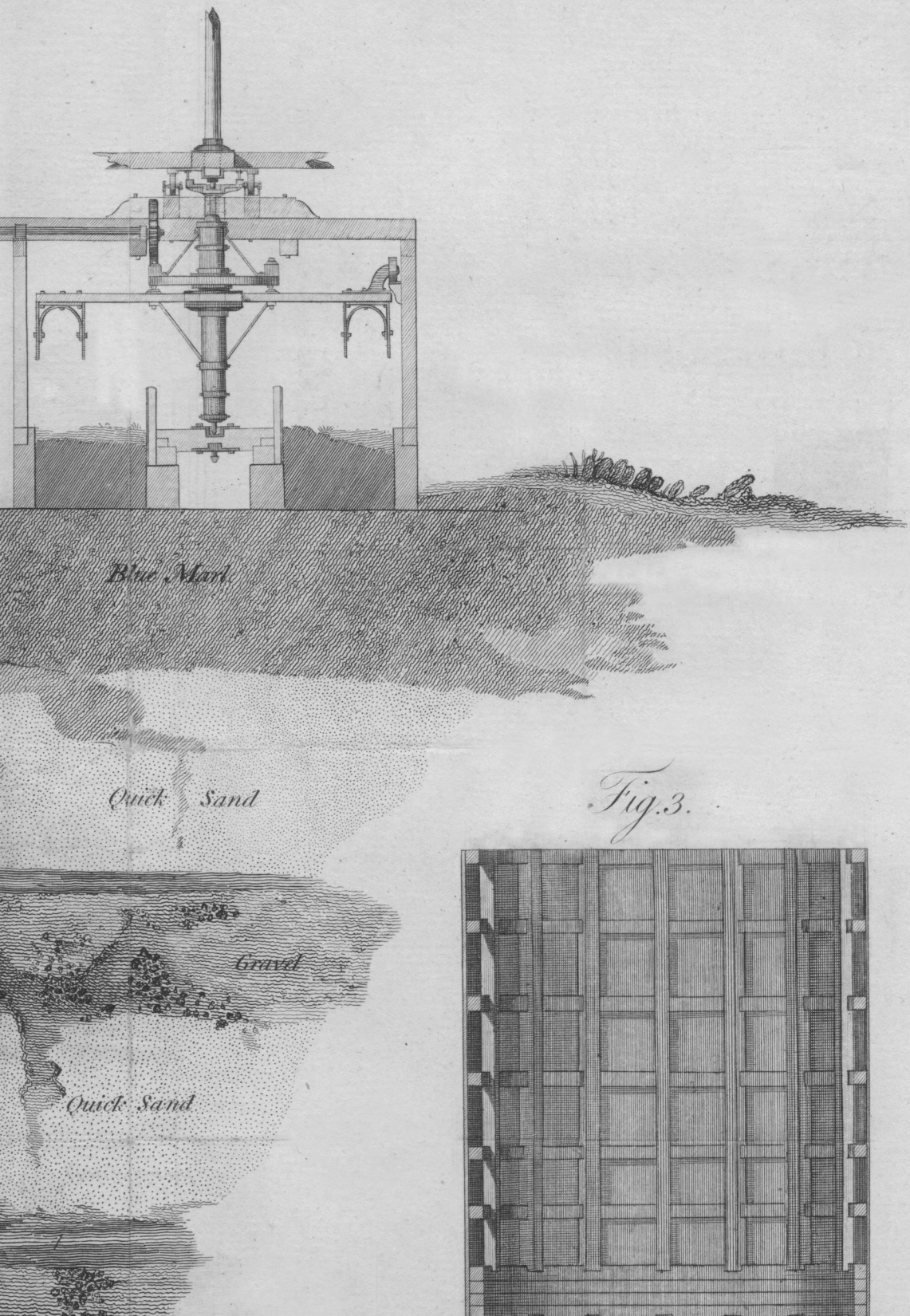
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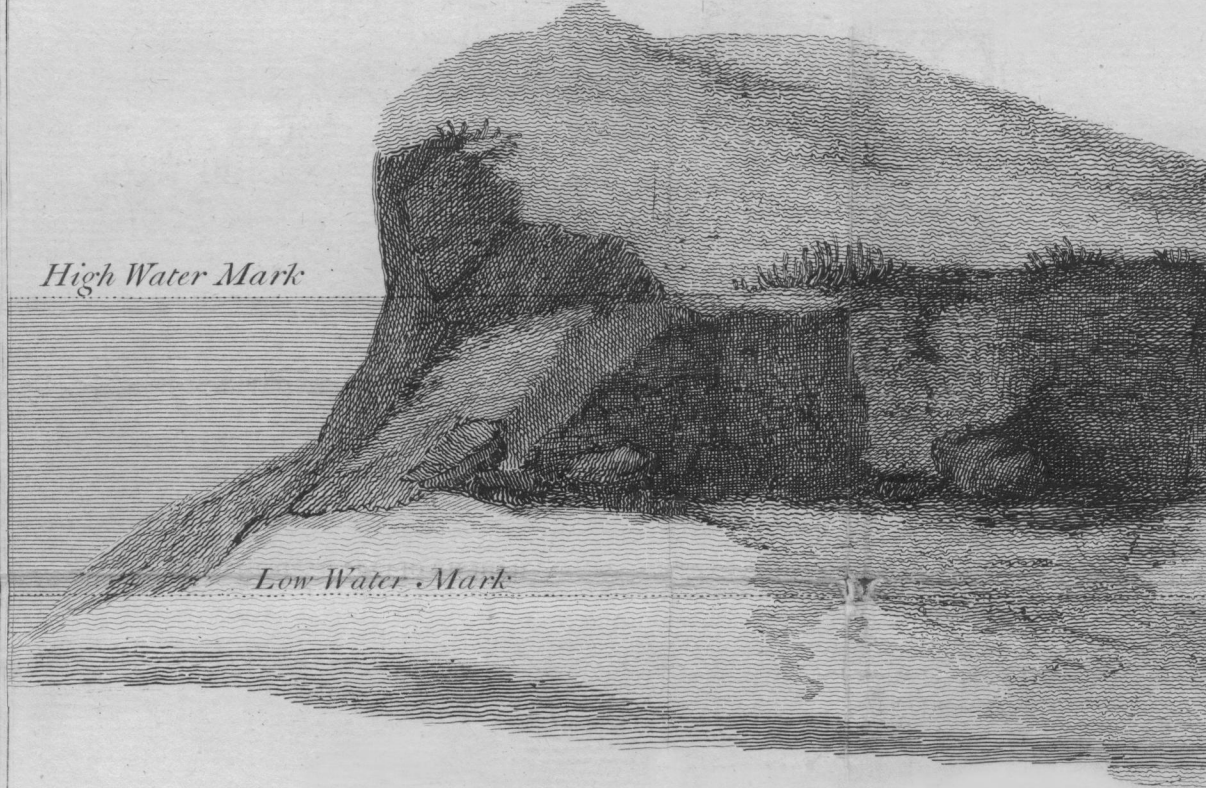


Fort Townshend Sheerneck.

Fig. 1.







High Water Mark

Low Water Mark

Fig. 4.

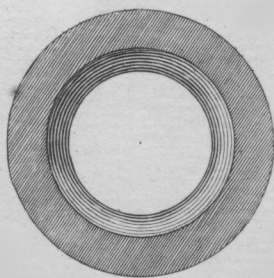
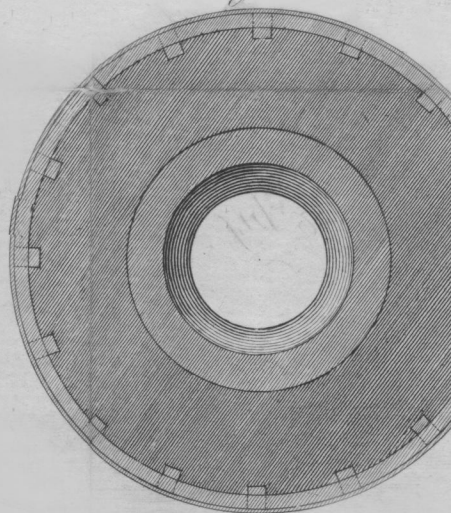


Fig. 2.



Scale 8 Feet to an Inch .

Fig. 1.

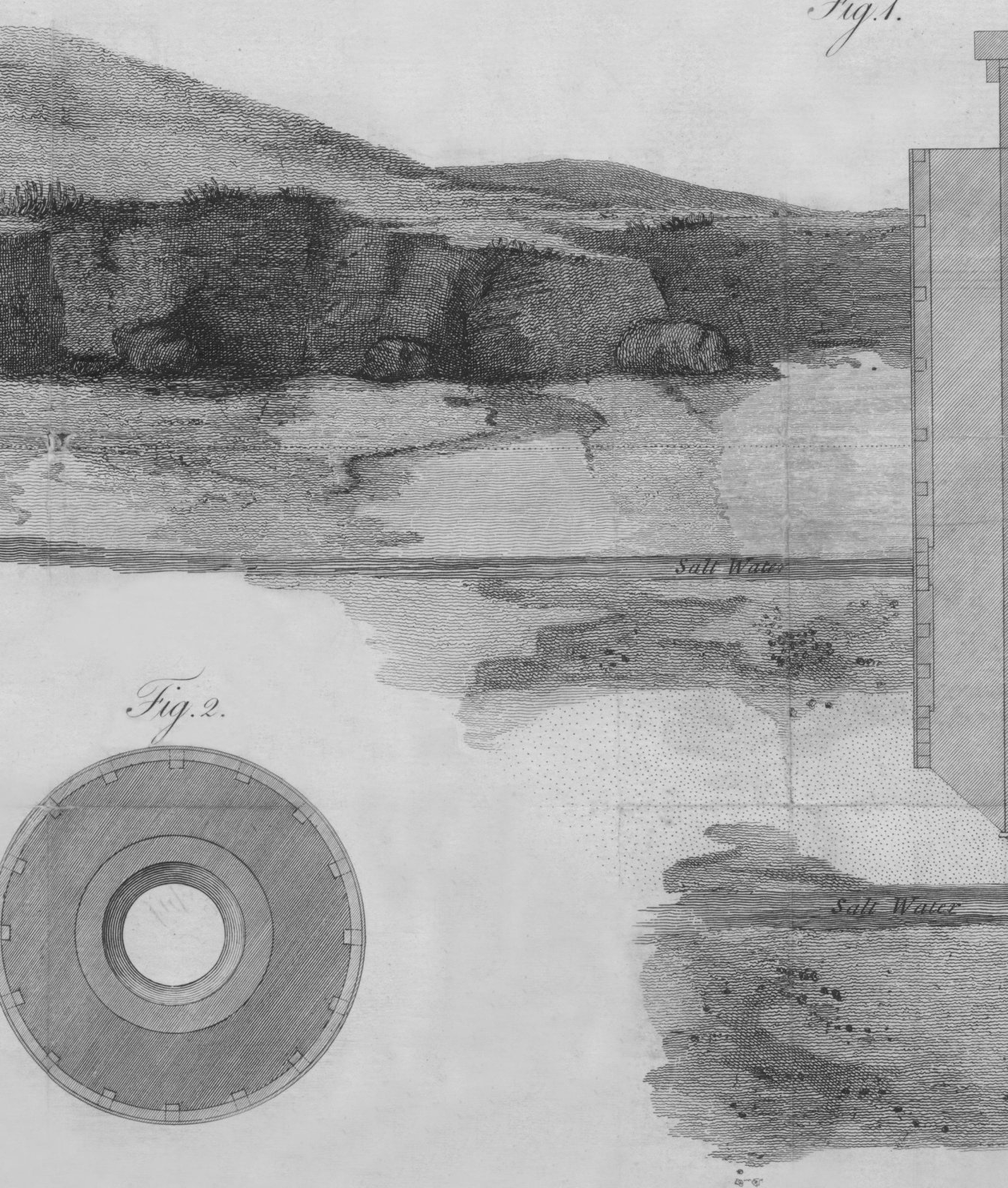


Fig. 2.

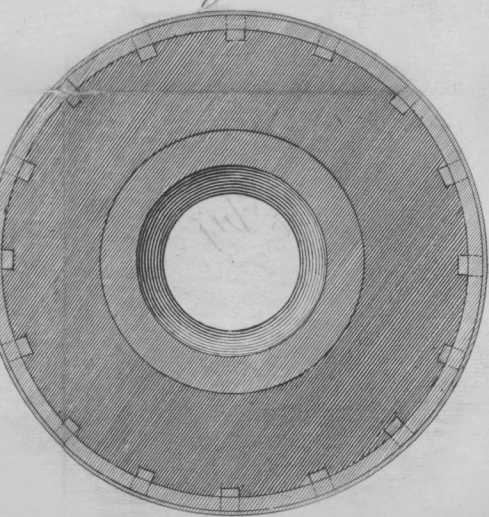
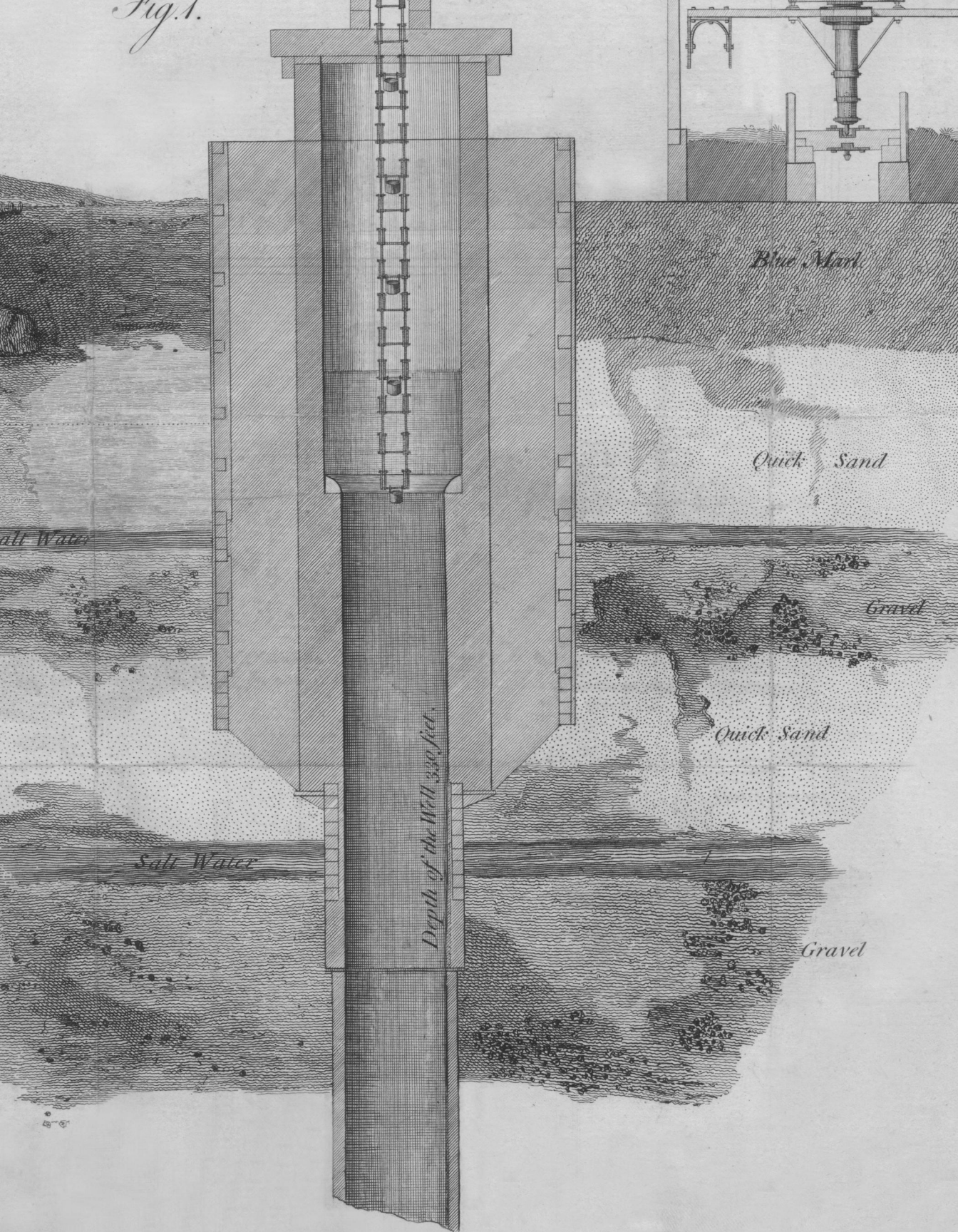
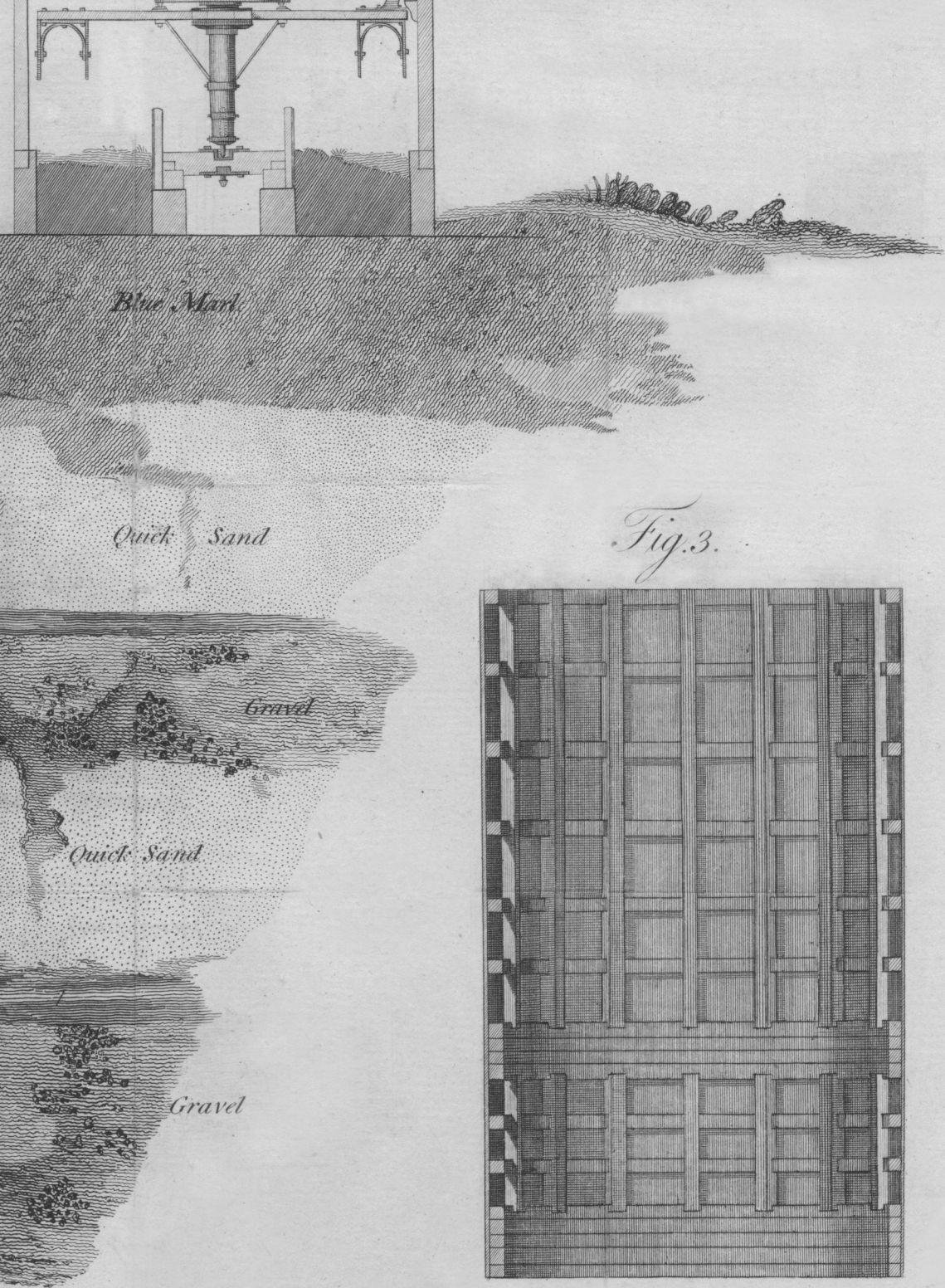
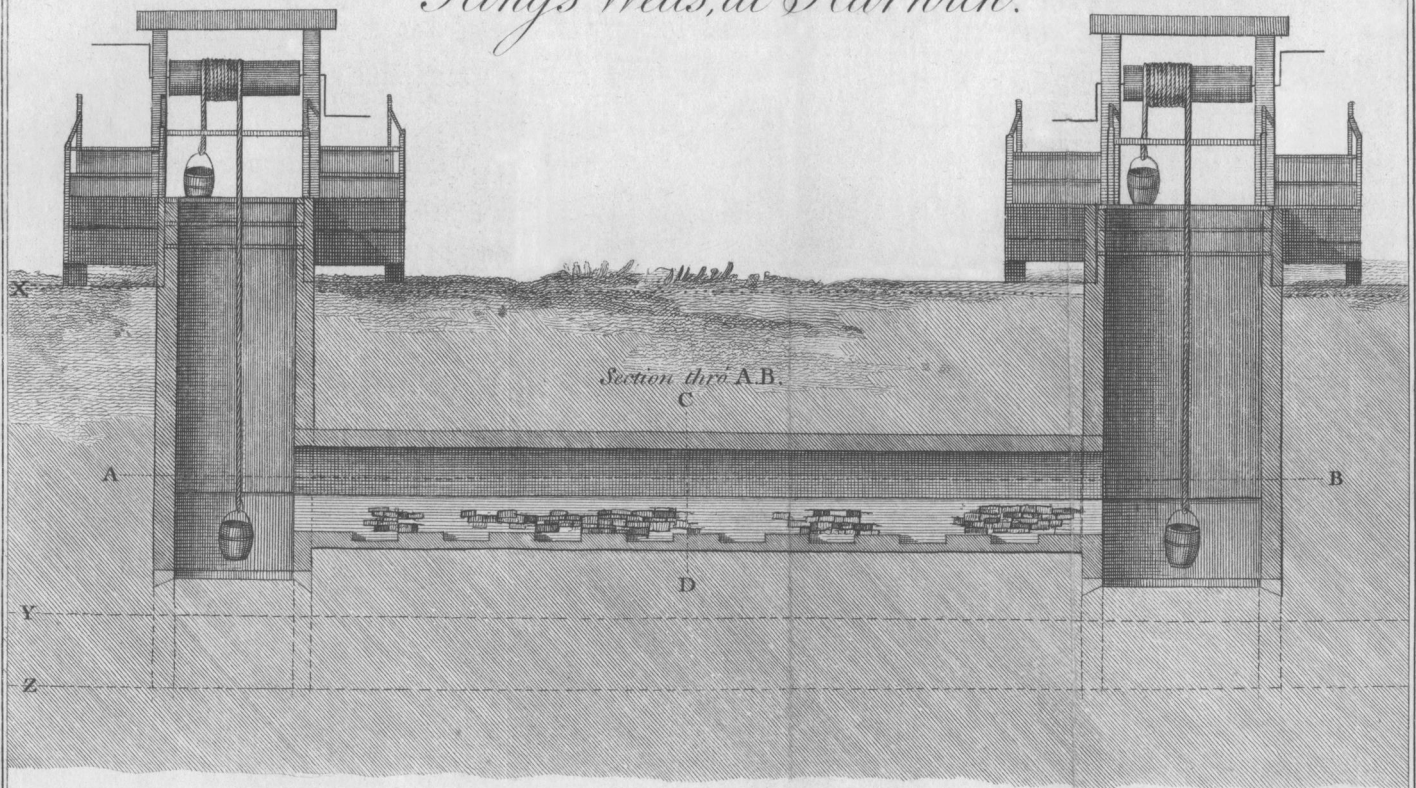


Fig. 1.

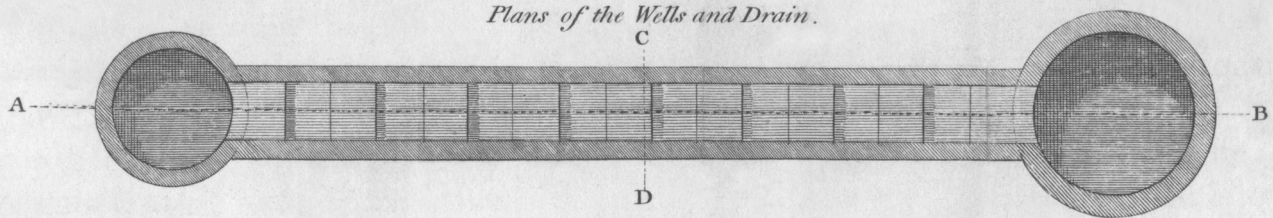




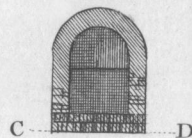
King's Wells, at Harwich.



Plans of the Wells and Drain.



Section of the Drain, C.D.



Scale 8 feet to one Inch.

B. J. Sc.